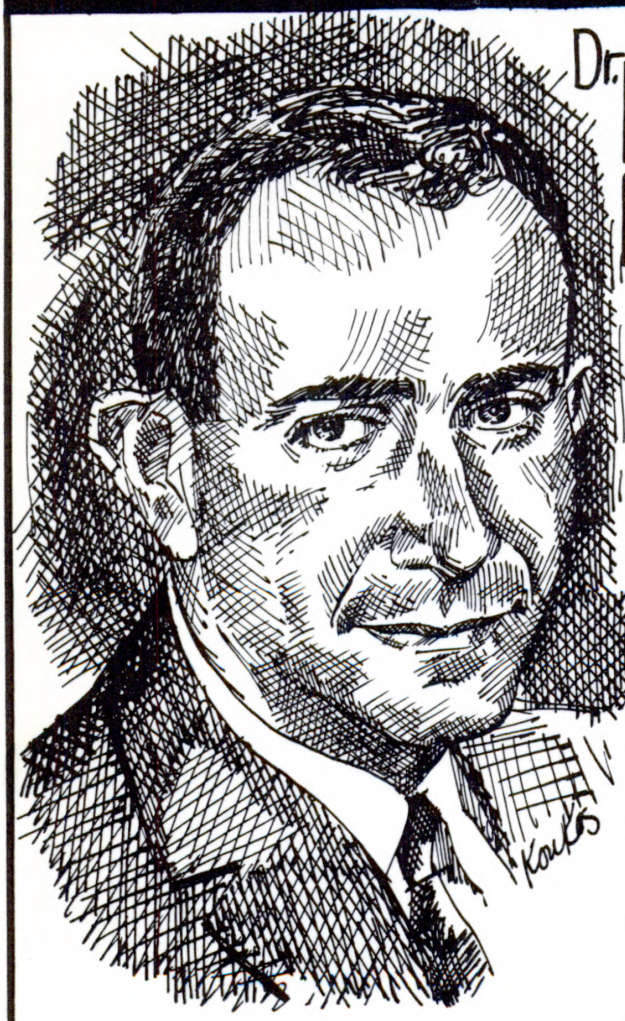
NAVAL RESEARCH

REVIEWS

JULY 1967

Portraits in Science



Dr. Herbert Friedman, of the Naval Research Lab,

is one of the nation's outstanding astrophysicists.

His work in rocket astronomy has led to many important discoveries.

Since 1949 when Dr. Friedman conducted his first experiments with V-2 rockets, he has participated in over 100 rocket and satellite launchings. These experiments have traced the solar cycle variations of x-ray and ultra-violet radiations from the sun, produced the first x-ray and ultra-violet photographs of the sun, led to the discovery of the hydrogen geocorona and measured the ultra-violet fluxes of early-type stars.

Among Dr. Friedman's many awards are the Navy's Captain Robert Dexter Conrad Award for scientific achievement and the President's Award for Distinguished Federal Civilian Service.

ONR's Role in Human Factors Engineering

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The purpose of this article is to acquaint the reader with the field of Human Factors Engineering and to provide a brief description of the role that the Office of Naval Research has in contributing to this relatively new discipline.

Human Factors Engineering focuses attention on the human component of equipments and systems, and considers man as an integral functional part of the man-machine combination. Because of his superior capacity for sensing, controlling, improvising, and decision-making, man, when properly employed, has great potential for improving system performance. On the other hand, he also may contribute to system degradation, particularly if his capabilities and limitations are not recognized and taken into account adequately during system definition, design, fabrication and operation.

Definition

Human Factors Engineering also is known as Human Engineering, Engineering Psychology, Biotechnology, and similar terms. For purposes of this article, it will be defined as "that field of scientific and engineering endeavor concerned with the role of humans in man-machine systems, the capabilities and limitations of humans relevant to performing particular tasks, and the requirements which must be met to insure compatability between the man and the equipment to be used by him."

The interdisciplinary (behavioral, biological, and physical) nature of the science requires the human factors specialist to possess a truly diversified background. He must not only understand the technical aspects of a system but also must have an appreciation and grasp of the limitations and assets of man. Most human factors specialists receive their training primarily in the behavioral sciences, which includes courses in scientific methodology, statistics, biology, physiology, and psychology. In addition, many have academic minors in physics, mathematics, engineering and other sciences. Conversely, many specialists in the field have had academic majors in engineering and the natural sciences, with some training in the behavioral sciences.

History

Human Factors Engineering emerged as a separate field of endeavor during World War II. This emergence was due to the rapid advances in technology and to the increased demands for more effective systems. Initially, the principal contributions made by this new discipline were in the design of aircraft flight instruments and other aircraft subsystems, air traffic control equipment training devices, and shipboard electronic equipment.

The Navy in general and ONR in particular have played a pioneering role in the development of Human Factors Engineering. The Navy's early and active role can be attributed largely to the efforts of the late Dr. F. V. Taylor of the Naval Research Laboratory. Although only four Navy laboratories had active human engineering programs in 1946, a survey conducted by the Naval Material Command in 1966 showed that approximately 25 Navy commands and facilities are presently engaged in human factors engineering work.

The ONR Engineering Psychology Branch (Code 455) was formed in 1955 to "promote the utilization of human engineering principles in the design of Navy equipment through Bureau contacts, contracts, consultation, and by publishing a Human Engineering Bulletin." Subsequent to this, the Branch's expanded role has included emphasis on the development of human engineering data and principles.

Human Factors Engineering Programs

The Navy's program in Human Factors Engineering falls into two general categories: (1) basic and applied research and (2) development, test, and evaluation in support of new and/or existing systems. The former is chiefly the responsibility of ONR, the Bureau of Medicine and Surgery, and their laboratories; the latter, of the Bureau of Naval Personnel, the Naval Material Command, the Systems Commands, and their laboratories.

ONR's Engineering Psychology Branch program currently emphasizes the following functional areas:

- Documentation and dissemination of human factors data,
- Controls and displays,
- Human-performance-augmentation devices,
- Mathematical modeling and simulation techniques,
- Decision making, and
- Performance assessment and criteria.

In addition, several studies are directed specifically toward the Navy's mission in strike warfare, anti-submarine warfare, command and control, and underwater exploration, *e.g.,* Man-in-the-Sea.

Documentation and Dissemination of Data

Despite the substantial amount of human factors data available to system planners and designers, all too often it is not used. Thus, several studies are being supported to improve the documentation, presentation, and dissemination of such data.

One such study is concerned with determining how and to what extent human factors information is used by system design personnel. Preliminary results have revealed a number of interesting observations. In the sample of designers tested, it was found that they do not routinely analyze the trade-offs or compromises necessary to achieve the desired design objectives before starting the actual design work. Further, these designers do not consider the functions to be carried out by various parts of the designed equipment, the importance of proper placement of critical controls and displays, and the relationship resulting from their sequence and frequency of use. Rather, they view their task, principally, as fitting specified items of hardware into a given work area. They are concerned about human factors only when a problem concerning limitation in available workspace arises. Their primary source of information is the design specification. Even when other sources of data, such as handbooks, are available, they rarely use them. Since the sample from which these observations were made was small, it is not possible to draw sound generalizations with respect to all designers. Additional work in this area is continuing and will serve to determine whether these preliminary findings can be generalized to a larger population. In addition, it will provide useful insights on how to improve presentation of human factors data, particularly in documents such as standards, specifications and design handbooks. The results of this research will have a direct influence on the revision of the Joint Services *Human Engineering Guide to Equipment Design*, a project currently being sponsored by the Branch.

Another ONR effort in information dissemination is the establishment of the Navy Human Factors Institute. To date, seven such Institutes have been held. The Institutes, which are limited to 50 attendees, are sponsored by the Engineering Psychology Branch and conducted with the help of other Navy commands and laboratories, and contractor personnel. Their purpose is to acquaint Navy civilian and military personnel with current human factors research, development, and evaluation programs, with special attention being given to the manner in which human factors scientists contribute to the solution of Navy problems and to the development of improved systems. The response to this program has been highly favorable.

The Branch also sponsors problem-oriented seminars. The first such seminar, held in March 1964, considered the problem of low-altitude,

high-speed flight. The meeting was attended by approximately 50 persons, ranging from basic researchers to Navy and Air Force pilots with extensive experience in flying low-level missions. The meeting was conducted on a relatively informal basis, thus permitting a maximum amount of discussion and off-the-record comments.

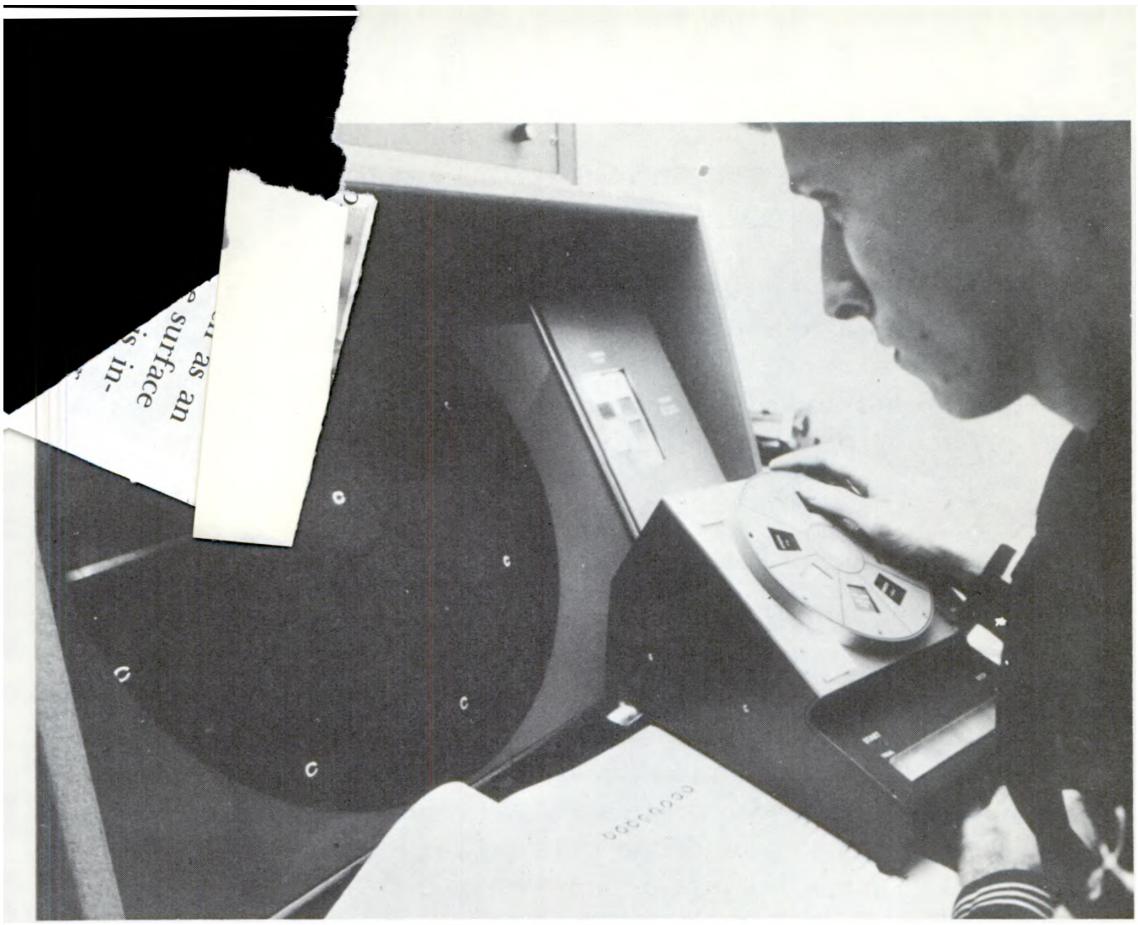
A similar meeting, which focused on human performance capabilities in undersea operations, was held in early 1965 in response to the growing need for ascertaining the role of man and his performance capabilities in an underwater environment. This meeting permitted not only the exchange of technical information among various disciplines, but also a discussion of particular problems between operational personnel, *e.g.,* divers and salvage officers, and research personnel.

A third such meeting, on selected human factor anti-submarine warfare problems, brought together naval personnel from the Fleet, the Office of the Chief of Naval Operations, and various laboratories. The result of this seminar was the establishment of a closer working relationship among the participants. It also led to ONR's providing additional support to studies of human performance in ASW systems. Such studies are being closely coordinated with the Office of the Chief of Naval Operations; Commander ASW Forces, Atlantic; Commander ASW Forces, Pacific; and the Naval Training Device Center. In this regard, one ONR contractor is actively working with personnel of the Commander, Fleet Air Wings, Atlantic in applying an information-processing model developed under ONR contract to ASW aircrew functions.

Displays

Because of the tremendous advances in general electronic and computer technology, the amount of information available to the men operating our modern weapon systems is, at times, overwhelming. Thus, out of necessity, most of this information must be presented in the form of a visual display. For this reason, the Engineering Psychology Branch has continued to support several programs in an effort to improve display systems.

An ever-present problem is that encountered in long-term monitoring of displays. Numerous studies have shown that an operator searching for targets on a cathode-ray tube, such as a radar scope, spends much more time searching the center of the tube or scope than the edges. By rotating a pie-shaped wedge along with the radar beam, thus reducing the amount of space to be searched, the number of targets located increases significantly. The detection of targets improves even more if the tube is physically rotated with the sweep of the beam, thus permitting the observer to search in the same location without visually following the target. A second study, also designed to alleviate



One study designed to alleviate the target detection problem utilizes a multi-phosphor cathode-ray tube

the target detection problem, utilizes a specially designed multi-phosphor cathode-ray tube. This tube has eight differently colored phosphors, with seven of them being arranged in pie-shaped wedges and one in the middle. The purpose of this study is to determine whether a target that changes color as it moves from one area of the tube to another is easier to detect than one on a conventional one-color tube.

Other display studies being supported relate to such areas as color coding and symbology as they apply to the design of charts and briefing aids. Because of the increased speed of our low-flying aircraft, the pilot has more information and less time to view and absorb it than ever before. It is essential, therefore, to put the information in a format which can be accurately and quickly read. In this regard, one study is designed to determine what there is about a target that makes the observer look "there" next. Along these same lines, some investigators are studying multi-dimensional coding techniques for visual displays. If the absolute number of symbols required can be reduced by manipulating the size, shape, and color, significant improvements in performance should result. The use of electroluminescent displays likewise is being investigated as a substitute for conventional displays where power and size limitations are present.

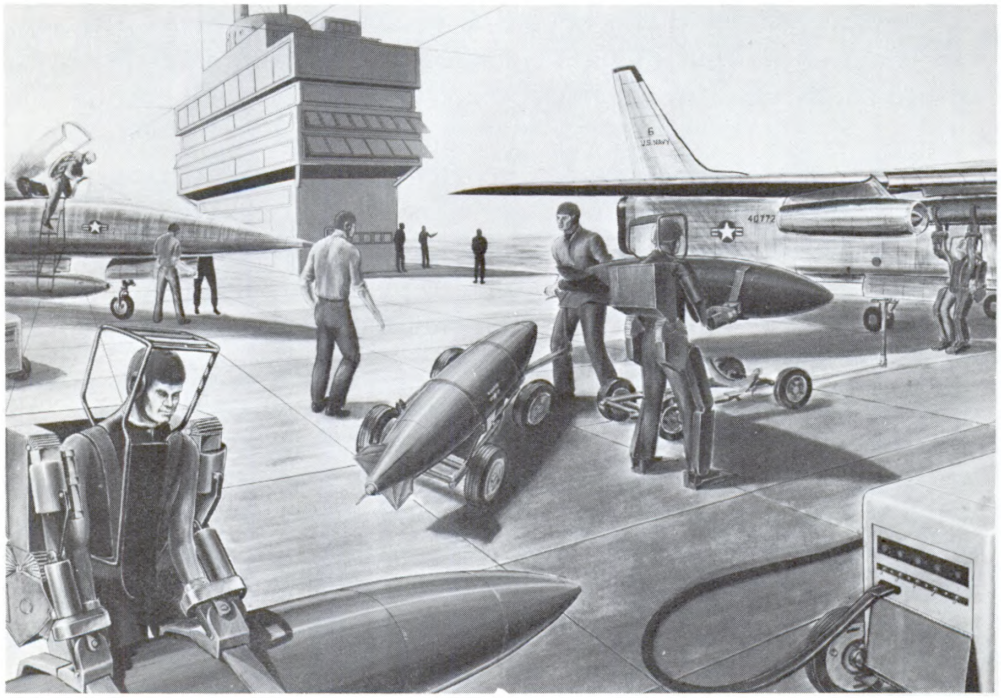
Wherever possible, novel approaches to displa
couraged. One such study involves the utilization
as an image-enhancement technique. If an image, eit
or otherwise, is placed on a surface in a stretched stat
inflated balloon), the density of the image is increased as th
is relaxed. As a result, the edges appear sharper, and contrast
creased. It is hoped to use this concept in conjunction with othe
methods being studied to enhance images or information in such areas as photo-interpretation, sonar, radar and satellite weather reconnaissance.

Human-Performance-Augmentation Devices

One of the more fascinating research projects currently being supported concerns the development of a powered exoskeleton. This research is being jointly sponsored by the Army and the Navy.

Worn as an outer mechanical garment, the exoskeletal structure will be powered to dramatically amplify the wearer's strength and endurance by a factor of approximately 25 to one, *i.e.*, when the exoskeleton wearer lifts 25 pounds, he will "feel" as if he is lifting only one pound. The device will provide him with a set of "mechanical muscles" that enable him to lift and handle loads in excess of 1000 lbs. The human operator will "feel" the objects and forces he is working with almost as if he were in direct body and muscle contact. This feature,

The powered exoskeleton should prove useful in cargo-handling and armament-loading



called force feedback, will provide the operator with sensitive control of the structure and will act as a safeguard against the application of excessive force.

The exoskeleton, called "Hardiman," mimics the movements of its wearer, presenting a literal union of man and machine. Thus, the human's flexibility, intellect, and versatility are combined with the machine's strength and endurance.

The applications of this device appear to be many and varied. The most obvious use would be for cargo-handling and armament-loading tasks in confined spaces. Another promising application is for underwater construction, salvage and rescue operations. In addition, consideration is being given to removing man physically from the structure and having him control it from another location. This would be particularly useful in hazardous environments such as areas with high levels of radioactivity and toxicity.

Mathematical Modeling and Simulation Techniques

Over the past several years, a substantial amount of research has been aimed at developing and applying more precise and quantitative methods for evaluating the role of single and multi-operators in man-machine systems. This work has led to the development of mathematical modeling and simulation techniques that take into account such variables as:

- Experience, fatigue, stress, and alertness;
- Operator loading (amount of work required), duration and scheduling of work-rest-cycles;
- Equipment reliability; and
- The relation of these factors to operational parameters, *i.e.*, speed, depth, altitude and task loading.

With the cooperation and contract support of the Bureau of Naval Personnel and the Naval Ship Systems Command, some of these digital-computer-simulation methods currently are being used to assist in the determination of personnel requirements as well as in the design of new Navy equipment and systems. The distinct advantage of these models and methods is their usefulness in predicting system performance and in evaluating alternate system designs before costly commitments are made for engineering and fabrication. Thus, these methods represent valuable tools for system planners and designers.

Field Testing Methods

With the cooperation of the U.S. Naval Test and Evaluation Force, research is being supported to develop improved methods for conducting

human factors evaluations of equipment and systems under operational conditions. This area of work represents a number of difficulties and challenges for both the naval officer and the scientist. In the operational evaluation environment, there are severe limitations of time, manpower and equipment, as well as difficulties in establishing conditions for rigorous scientific investigations. It is expected that this study will provide improved guidelines which will contribute to the Navy's field-testing practices and eventually provide a basis for improved equipment design from the human factors engineering standpoint.

Man's Performance Under the Sea

Much has been written in the past year on the general subject of oceanography. There seems to be agreement, both scientifically and politically, that the oceans hold within them an important part of the future for the human race. However, it has been only in the past few years that man really has begun to conduct extensive studies and explorations concerning man's abilities to live and work in the underwater environment.

Reference here is primarily to the work of CAPT Jacques Yves Cousteau of the Institute Oceanographique, Monaco, and to the U.S. Navy's Man-in-the-Sea Program. Now that it is becoming possible for man to remain in the sea for weeks or months at a time, studies must be made of his capabilities and limitations in this extremely hostile environment. For this reason, in the past year, the Engineering Psychology Branch has undertaken six new programs designed to determine man's performance capabilities as an undersea inhabitant and worker.

Since one of the most limiting factors in underseas endurance is cold, one program is concerned with the effects of cold on diver performance. Although research is being conducted to develop heated diving suits, it is essential to ascertain just where the heated suits should be used, as well as the tradeoffs which must be considered. Work to date has been conducted in closed water-filled chambers and open quarries with water temperatures ranging from 42-76°F. Initial results indicate that cold causes a sharp drop in performance, particularly in ability to maintain attention for even short periods.

Another rather interesting study underway involves the ability of divers, when confined in a wet (water-filled) submersible for extended periods, to perform such tasks as navigation, vehicle control, and reconnaissance. Although performance in such a situation causes much stress and almost forces man to the limits of human endurance, such requirements are essential to military operations.

Behavior studies were made of Sealab divers via closed-circuit TV

Studies also are underway to measure diver performance in operational situations (both commercial and military); to develop a special performance battery of tests for use at the U.S. Navy Deep Sea Diving School; and to measure force and horsepower output of divers performing heavy undersea work.

Note: In addition to the undersea contract program described above, Dr. James W. Miller is responsible for the human-performance program for Sealab II and Sealab III. (The Sealab II experiment was completed in October 1965 and the open-sea operations of Sealab III are scheduled to start in late 1967.) This program includes the measurement of diver performance in the water, the collection of data during training, and the observance of behavior inside the habitat during the entire experiment via closed-circuit television. The contract program is designed to augment information gained during Sealab experiments as well as other Man-in-the-Sea Programs.

Other investigations are being conducted in such areas as vehicle-control dynamics, air-to-ground guided missile control, electroluminescent displays for aircraft, development of criteria for evaluating the effectiveness of displays, and the measurement of the creativity of engineering personnel. No attempt has been made to review each of our programs in detail. Rather, the purpose has been to present an overall flavor of the nature of the Human Factors Engineering program being supported by the Branch.

Future Trends

The future will find the Navy in new operating environments, resulting from both new capabilities and new missions. The Navy's

involvement in "inner space," *i.e.,* the ocean depths, is well-known. Ocean-bottom colonies for tactical and resource-exploitation purposes soon may be a reality. Also, military missions planned for the future—in space, in polar regions, and possibly even on other planets—will confront the human factors specialist with a host of new problems. Some of these problems include:

- Work-rest cycles where there is no natural night-and-day cycle;
- Workspace configuration and layout for crews who must live together in confined spaces for very long periods; and
- Physical and intellectual performance capabilities of men doing useful work in hostile environments which restrict normal operation of the senses and range of movement, or which require life-support systems that stress the body in as-yet-unknown ways.

Today's advancing technology has just begun to revolutionize the man-machine environment. Based on experimental work at the Massachusetts Institute of Technology, desk-top computer terminals soon may become an every-day working tool of the scientist and engineer, helping him to eliminate routine chores, solve problems, analyze data and actually design systems. The man-computer partnership already has concerned the human factors specialist with the question of how personnel who lack special aptitudes and training can carry on a productive "conversation" with the computer. This problem has generated research aimed at developing "natural languages" for addressing a computer. In this regard, typewriter-like keyboards have been developed where one can type out questions or instructions in normal English and have an answer automatically in a matter of seconds.

It has been found that, by writing directly on a cathode-ray tube with an "electronic pen," a designer may sketch particular design configurations, specifying at the same time a range of permissible parameters. The computer can, almost instantly, mathematically analyze the information, make necessary trade-offs, and sketch or print-out numbers, curves or configurations representing desired structural and functional requirements, *e.g.,* size, weight, shape and power. After reviewing the computer's output, the designer can make any changes he wishes, insert new information and request another computer analysis and evaluation. This man-computer cycle can be repeated as often as desired, allowing continual updating and refining of data.

It is hoped that the computer of the future will contain in its memory-store established human-factor design principles and mathematically-expressed data on human-performance capabilities. Such a computer facility will go a long way towards insuring that human factors data are appropriately considered in system design.

Through the Years With FLIP

LCDR John J. Kirk
Undersea Programs
Office of Naval Research

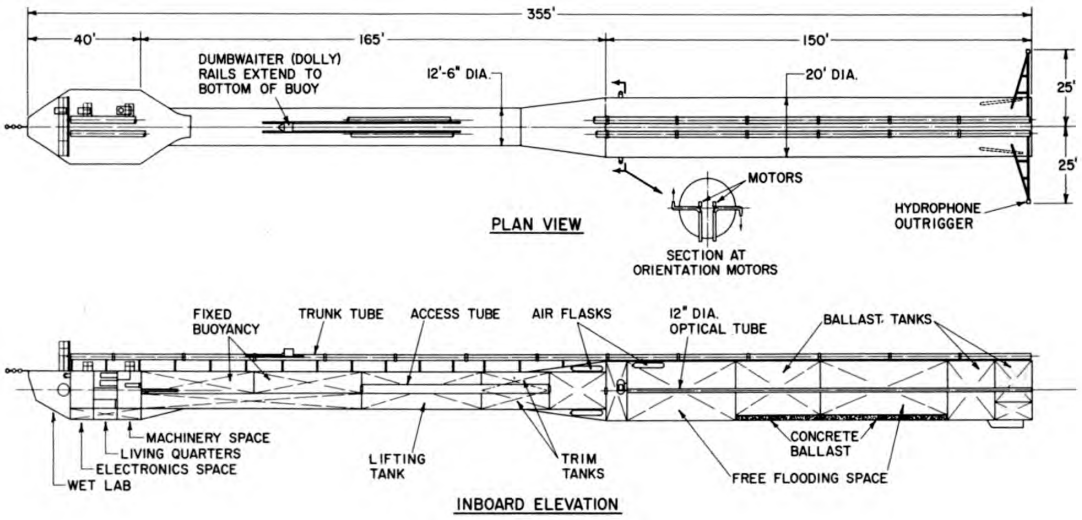
FLIP, the Floating Instrument Platform operated by the Scripps Institution of Oceanography, is approaching its fifth operational birthday. Forty-five expeditions have been scheduled and completed during those five years. One hundred fifteen "flips" have been made and over 360 days have been spent at sea. It is safe to say that this rather crude prototype research buoy is a success.

The need for a stable open sea working platform had been apparent for some years. Several ideas for building such a structure had been advanced. One suggestion was to upend a submarine, placing enough weight in the stern so that only a small portion of the bow would protrude from the ocean surface. In 1960, FLIP was conceived by Dr. F. N. Spiess, Director of the Scripps Marine Physical Laboratory and CAPT C. B. Momsen, Jr. of the Office of Naval Research assisted by other scientists from MPL and Navy-oriented organizations.

FLIP was to be a huge cylindrical structure, so designed that it could be towed to sea in a horizontal position and then upended by flooding ballast tanks in the stern. The portion of the buoy that remained above the water would contain laboratories, living quarters and an engineering space. When it was time to return to home port, the vessel would be "flipped" back to its horizontal position by blowing the water from the ballast tanks.

After MPL scientists had completed a theoretical study of some of FLIP's more critical features, the initial design for the platform was worked out by M. Rosenblatt and Sons. The final specifications and working plans were completed by L. R. Glosten of Seattle. Finally, construction of the platform was turned over to the Gunderson Brothers Engineering Company of Portland, Oregon. Throughout the designing and building stages, financial support was provided by the Office of Naval Research and the then Bureau of Naval Weapons through the Naval Ordnance Laboratory STAG (Subroc Technical Advisory Group).

Construction began January 1, 1962 and FLIP was launched, on schedule, on June 22 of that year. Operational tests were commenced on July 19 in the Dabob Bay facility of the Keyport Naval Torpedo Station near Seattle, Washington. Delivery was made on August 6 and FLIP arrived in San Diego nine days later. Open sea operations were commenced in October 1962 off San Clemente Island.



FLIP is 355 feet long and weighs about 600 tons. When the vessel is in the vertical or "working" position, the research laboratory, living quarters and engine room are located at different levels above the water line – 30 ft, 22.5 ft and 15 ft, respectively. An open-grill platform located outside the research laboratory is used to make surface observations, to handle small boats alongside, and as a safety station during flipping operations. A second, higher platform is used to lower equipment through a two-ft diam trunk tube that runs the entire length of the cylinder. Such a procedure keeps the equipment free from becoming entangled with the buoy or with externally mounted gear. Two other watertight, ladder-equipped tubes which extend from the cabin downward to an ocean depth of 150 ft are used by the crew to carry out certain tests or to check on the operation of the buoy.

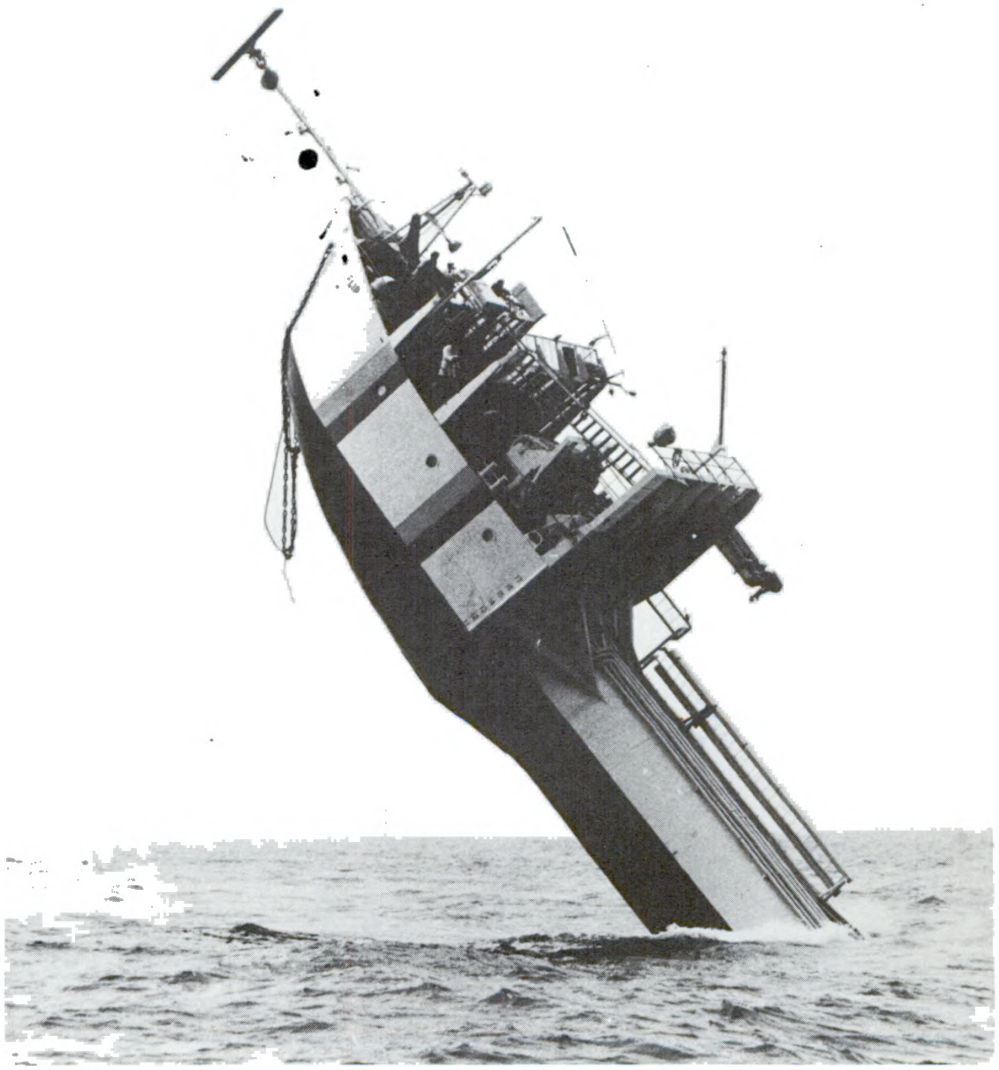
A 12.5-ft diam steel cylinder, which extends 100 feet below the ocean surface, supports the cabin. Attached to this cylinder is a cone-shaped section, flaring outward and downward for 50 feet until it becomes a 20-ft diam cylinder which extends downward to the full 300-foot draft. It is this 60 percent reduction in diameter that occurs within the buoy that gives the platform a natural period for heaving which lasts about half a minute.

During its five-year career, FLIP has been extremely popular with the various scientific groups. Successful research has been performed in wave attenuation, ambient sound, seismic wave recording, internal wave measurement, bearing accuracy phase fluctuations, microthermal recording, current measurements, and in several classified projects. During this time, the platform has been continually upgraded to meet the ever-increasing demands of the scientific groups. Equipment added to make FLIP more useful to the various groups has added some

40 long tons to the upper areas, thus making it necessary to add more ballast to maintain horizontal stability. Major additions include radar, Loran, SSB radio, extendable booms, an orientation system, additional platforms, extensions to original platforms, winches, capstans, ventilators, an additional engine and air compressor, a low pressure blower, and more galley equipment. The living spaces have been improved so that FLIP can now accommodate 14 persons instead of the original ten.

FLIP has made two long expeditions to the Hawaiian area and one to the North Pacific. Original design criteria called for only a two-week duration at sea. However, during its trip to the North Pacific, in mid-1963, FLIP was at sea for 45 days, with 27 of them vertical and on station. Ten men, six crew members and four scientists, subsisted with relative comfort during this entire period.

FLIP is upended by flooding ballast tanks in the stern



The Scripps research ship HORIZON towed FLIP to her station, 1500 miles north of Hawaii. During the trip, the vessel and her crew encountered 35-ft waves and 50 mph winds. The on-station transition to vertical was made in 20-foot seas.

One portion of this expedition included a part of a summer-long project of the San Diego branch of the Institute of Geophysics and Planetary Physics. The project collected measurements of southern sea swell and its attenuation at six locations in the Pacific. The other five observing stations were on islands. FLIP recorded swell from storms occurring almost half a world away, deep in the Southern Hemisphere. During the entire period FLIP was in operation, HORIZON stood by making additional oceanographic investigations. FLIP drifted only 55 nautical miles during this period; its vertical excursion was found to be less than three inches.

FLIP made expeditions to Hawaii in 1966 and 1967. The 1966 expedition was called "Kani," the Hawaiian word for "sound" or "noise." Sonar bearing accuracy experiments provided the major impetus for these trips. In addition, FLIP served as a quiet, drifting platform from which scientists observed and recorded ocean, ocean-bottom and biological noises; conducted seismic studies; measured the rate of heat transfer from the earth to the ocean (in connection with the final selection of a drilling site for Project Mohole), observed distortions of acoustic signals reflected by the ocean floor, and conducted sound-propagation research. This expedition lasted from March through September. Several times during both this trip and the 1967 excursion, FLIP remained on station with no attending vessels for periods in excess of 15 days. Other than those long duration trips, FLIP has made many short trips for various research projects to the ocean areas off the California coast.

The vessel is normally manned and maintained by a crew of six. These men are on board during transit as well as on station. The scientific party is also usually on board, since transfers at sea are extremely hazardous. They are rarely attempted unless operations are conducted in protected waters.

Because of the hard usage encountered through the years, FLIP will be drydocked in summer 1967. After this overhaul is completed, the unique vessel will return to station and continue its task of research in underwater acoustics, seismology, gravity and magnetic studies—all aimed at improving the Navy's capabilities in antisubmarine warfare.

The Third Cryopreservation Conference will be held at Washington, D.C., August 7-10. Additional information on this conference, which is sponsored by ONR, may be obtained from Dr. K. Sell, NNMC, Bethesda.

Research in the Delta Lowlands

Evelyn L. Pruitt
Head, Geography Branch
Office of Naval Research

Almost half of the world's coasts are plains. These areas, of generally low relief, extend seaward of the shoreline as shallow-water areas. The ten-fathom depth line is, in fact, typically more than five miles offshore.

Many of these plains are almost flat, dissected by sluggish rivers and tidal channels, and covered by marsh or swamp vegetation. Slightly more than ten percent of them are deltas, areas of active river deposition. It was on these low-lying alluvial plains and deltas that the ONR program in coastal geography first focused attention.

Research began in 1950 under a contract with Louisiana State University. In 1954, the Coastal Studies Institute was founded at LSU. Studies were made of the navigability and trafficability characteristics of deltas, using the Mississippi Delta as a field laboratory. At that time deltas and marshy coastal plains were considered essentially unusable for military operations, particularly for amphibious landings. ONR reasoned, however, that, since it is not always possible to pick the arena for military operations, efforts should be made to acquire knowledge of areas that pose particular military problems. Results of such efforts should improve naval capabilities in the event that operations were required in deltaic lands. Much of this thinking, of course, reflected experiences encountered during World War II. In any case, the deltaic lowlands presented many scientific challenges and were worthy objects of study.

From the beginning, the research emphasized the use of aerial photographs coupled with detailed field surveys to identify the physiographic and environmental units characteristic of a delta, and to determine the ways in which these units change under the influence of a variety of factors, *e.g.,* river floods and high tides. One of the first products of the study was a series of maps of coastal Louisiana which indicated areas of reasonably firm ground and controlling depths of navigable waterways. The study showed that natural levees of both active and abandoned channels form strips of firm ground which converge and become higher and broader as they lead inland. Between these narrow strips are low, wet, generally non-trafficable marsh areas, lakes or bays. For an area that is predominantly water-covered, surprisingly few natural waterways with depths in excess of three feet were found.

After the basic patterns were identified, steps were taken to investigate the processes that form and alter these patterns. General concepts were developed on the basis of measurements and observations

in the Mississippi Delta. However, to test the validity of these concepts, it was necessary to study deltas and other marsh areas that exhibit conditions of river discharge, sediment load, tidal regime, littoral currents, vegetation, and climate that are different from those in Louisiana. Investigations have, therefore, been undertaken on the Ganges-Brahmaputra Delta of East Pakistan and India; the Burdekin in Queensland, Australia; the Klang in Malaysia; and other alluvial coastal areas. These areas introduced such environmental factors as monsoon rains, mangroves, extremely low river discharge rates, extensive tidal inundation, and high population densities. All of these factors have to be taken into account in determining controlling processes.

The studies in tropical areas focused the Institute's attention on problems relating to the occurence of beach rock that presents potential hazards to landings, and coral reefs that influence beach processes. Considerable effort in recent years has been devoted to studies of beach processes. The studies conducted by the Institute are so unique that it has attained world-wide fame as an international center for coastal research.

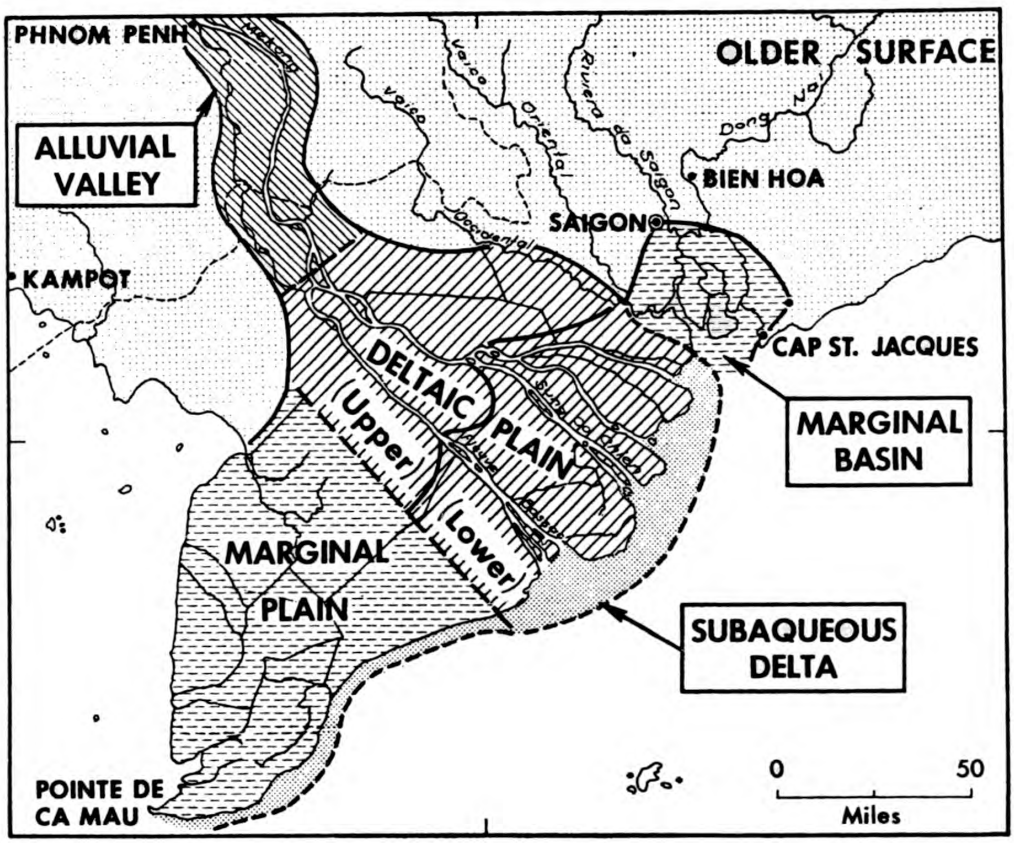
Meanwhile, ONR's Geography Branch expanded its contract support, not only for the Institute but also for other contractors engaged in studies of alluvial coasts. Investigations were conducted in the Guianas where marshes and mudflats are interlaced with beach ridges. Studies are being made of areas along the west coast of Mexico that are basically similar to the Guianas, but with some distinct differences, to discover the causes of these differences. Studies are also being made of the rates, times and causes of level changes in tidal marshes. Investigations were made of the factors controlling the origin of drainage channels and the processes by which these extremely complex systems developed in tidal marshes, using San Francisco Bay as a study area. Other studies include the mechanisms of sediment transport and the bottom forms in small estuaries which are subject to high tidal ranges, as in New England.

The purpose of all these studies is to develop fundamental concepts of the processes and modes of operations that account for the forms and rates of change in deltaic and low alluvial coasts. Such concepts can provide a basis for predicting land and waterway conditions in areas where superficially it is frequently difficult to distinguish between land and water.

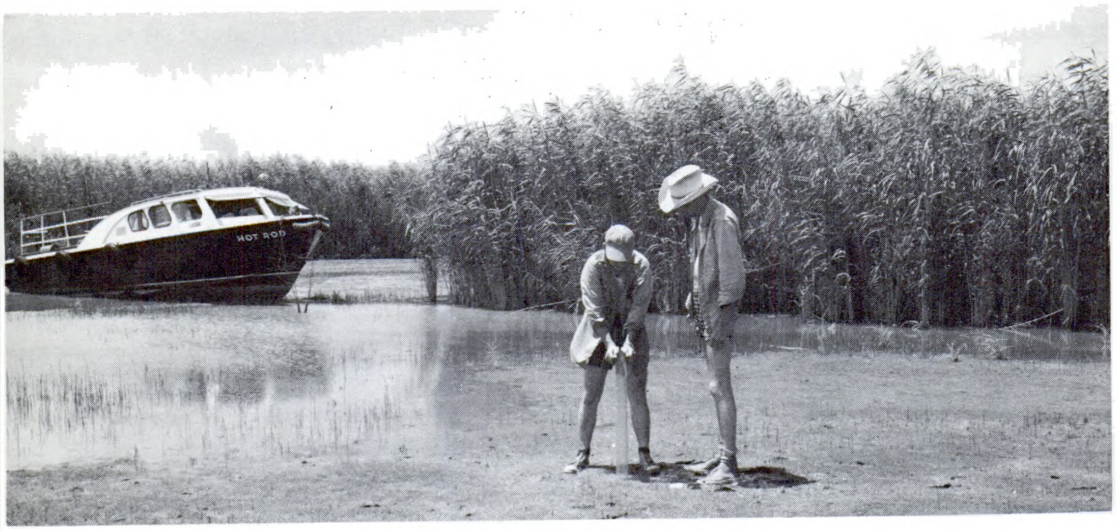
To date the research has generated a set of what may be called "diagnostic" principles. If, through careful scrutiny of maps and photographs, it can be determined that a particular form or condition exists in a coastal river system, then it follows that certain other conditions should be looked for or can be presumed to exist. The exact magnitude or detailed nature of these other, related conditions is not always predictable. However, from an operational point of view, it is extremely valuable to be alerted to localities having favorable or marginal conditions.

Deltas, like people, exhibit considerable individuality. As more and more deltas are subjected to detailed study, however, more and more common characteristics become apparent. The Mekong Delta, for example, has its own peculiarities, such as the Tonle Sap, which acts as a flood-water regulator and as a settling basin for sediments that would otherwise be carried by the river to its delta. Also, unlike many other deltas, *e.g.*, the Irrawaddy or Ganges, the major distributaries of the Mekong have few connecting waterways. Nevertheless, the Mekong Delta exhibits a large number of features common to most deltas. Even without detailed field study, the general characteristics of such features can be deduced from knowledge gained in studies made elsewhere. It is possible to predict, for example, areas of shifting shoals in the water courses, channel segments that will maintain deeper water or higher velocities, and erosion and deposition events brought about by tidal or river-flood action.

To assist in river pilotage in the Mekong Delta, the Coastal Studies Institute is now engaged in applying the accumulated knowledge gained over years of research to prepare a guide of deltaic river processes keyed to the Mekong. It is worth emphasizing that, in order to have the basic



Major components of the Mekong Delta



Collecting sediment samples in the lower delta of the Mississippi River

Drilling in the coastal marshes near Galveston, Texas

Tramping through the coastal marshlands. (All photographs reproduced courtesy of Coastal Studies Institute.)

Prof. R. J. Russell, former Institute director, examines basalt flows capped with coral and other cemented carbonate deposits.

knowledge available when the Navy needed it, the research had to be initiated many years ago. In dealing with the geographic environment, there is no substitute for long-term and widespread observations in determining whether characteristics are persistent or only transient, and in correctly identifying processes that have a high degree of universality. A quick-fix answer to an environmental problem more often than not is erroneous.

Within the past years, two new aspects have been incorporated into the research program on deltaic and riverine environments. Both involve extensive use of computers for data handling. One study is concerned with developing computer capability to simulate deltaic processes. The models are being designed to test theories of sediment movement and deposition by compressing time, thereby quickly presenting stages in the development of deltaic land and water features that would take nature from months to centuries to create. Thus, it will be possible to verify the environmental conditions which scientists believe govern deltaic behavior. In addition, these mathematical simulations should improve predictions of deltaic conditions likely to be encountered.

The second new undertaking concerns devising a computer-assisted system to store, analyze, manipulate, and display coastal information. Particular attention is being given to naval requirements for such information. Initial steps in the study were directed toward identifying these requirements and determining the degree to which available information meets these requirements. Although a considerable body of information is available, it is in a variety of non-compatible forms, *e.g.,* photographs, tables, articles, maps and charts. A major problem, therefore, in devising an information system is finding a way to extract the significant information content from these forms while, at the same time, preserving the locational, spatial and temporal aspects of the data. Although this work is just beginning, the magnitude of some of the problems is already evident. Nevertheless, the development of an information system is mandatory if the store of coastal information is to be made truly available. At present, information search, retrieval, and extraction is so time-consuming that in many cases the information might just as well be non-existent.

For the next few years the research program on alluvial coasts will continue the study of deltaic areas within and outside the tropics, with emphasis being placed on the development of information systems and predictive tools. In addition, it is expected increased studies will be concerned with arid coasts. These areas exhibit a variety of unique processes and, like deltas, are interesting objects of study.

Research Notes

Navy Research Study Leads to Warning of Explosion Hazard

A Navy-sponsored research study has shown that many high-energy liquid chemicals can explode accidentally. As a result, the Navy has issued a warning to all laboratories and chemical plants handling these or related liquids and has provided preliminary guidelines for their safe handling.

The danger arises from a little-known phenomenon called low-velocity detonation (LVD), which can be initiated by weak shocks. Ordinarily LVD results in the complete consumption of the liquid. The danger of LVD is due to its occasional transition to high-velocity detonation (HVD), which is equivalent to the detonation of commercial or military explosives, or to a rapid pressure build-up which leads to container rupture.

The first concerted effort to understand LVD was made several years ago by the U.S. Bureau of Mines, largely through a study devoted to nitroglycerine. Since then, LVD has been experienced in a wide variety of high-energy liquid chemicals, with some of the explosions reaching serious proportions. As yet, it is not understood why LVD exists in some such liquids but not in others. However, a recent study by the Stanford Research Institute sponsored by ONR has shown that LVD exists in high-energy fluorine liquid chemical compounds, which are under development as high-energy propellants, as well as in the better known explosive nitrogen compounds.

The results of the Navy research combined with the previous Bureau of Mines study of more conventional explosives, such as nitroglycerine, are the basis for the preliminary guide distributed by ONR, which outlines procedures for minimizing the risk of explosion.

The guide points out that in the case of some liquids the interaction of very weak waves, such as those that can result from dropping a container of the liquid, may be sufficient to stimulate initiation of LVD. Thus, when one of these liquids is being transferred, special care must be taken to eliminate possible sources of shock, such as liquid "hammer" from rapid-closing valves, cavitating pumps, or such activity as mechanical assembly and disassembly. The guide also warns that vigorous mixing, stirring or sloshing of the liquids or any conditions leading to turbulence and cavitation must be avoided.

Pools or thin coatings of the liquid allowed to remain on hard surfaces may be especially hazardous and should be avoided. LVD can propagate through small tubes or thin films of the liquid whereas a high-velocity explosion would die out. Exposure to heat should also be avoided since the sensitivity to initiation of LVD increases substantially with rising temperatures.

The guide also states that LVD is strongly influenced by the character of the material of the container. Low-density materials, such as plastic, and soft materials, such as lead, are considered more desirable for use as containers since such materials exhibit low sonic velocities.

Sonar Reverberations Measured

The Gulf of Mexico and western North Atlantic are currently the scene of ship-plane experiments to determine the effect of fish life and organisms on underwater acoustics. Scientists from the Naval Oceanographic Office, Suitland are directing these experiments from the USNS (T-AGOR-6), which has been equipped to collect samples and electronically record sound measurements.

The primary purposes of the operation are to determine the acoustic characteristics of layers that cause the scattering of sound, and to ascertain the distribution and abundance of organisms in those layers.

Air launched explosives and sonobuoys will be dropped from a plane to determine if reverberation measurements may be made effectively from the air. The effects will be recorded by both the ship and plane. The tests are expected to continue for about 30 days.

New Thesaurus Standardizes Technical Vocabulary Throughout Military and Industry

The Department of Defense in conjunction with the Engineers Joint Council will soon publish the *Thesaurus of Engineering and Scientific Terms*. This work represents the first effort to standardize in one volume the technical vocabulary used by military, industry and the academic world. Publication of the volume this summer will be the culmination of an 18-month project known as Project Lex. Manager of the program for the Department of Defense was the Office of Naval Research.

Previously the variety of meanings given to major terms by different scientific disciplines has hampered the interchange of technical information. This has been further complicated by the number of new terms and phrases created in recent years. A standardized technical vocabulary is also needed to provide precise terminology for computer information systems, especially where information networks and storage and retrieval systems cut across interdisciplinary boundaries.

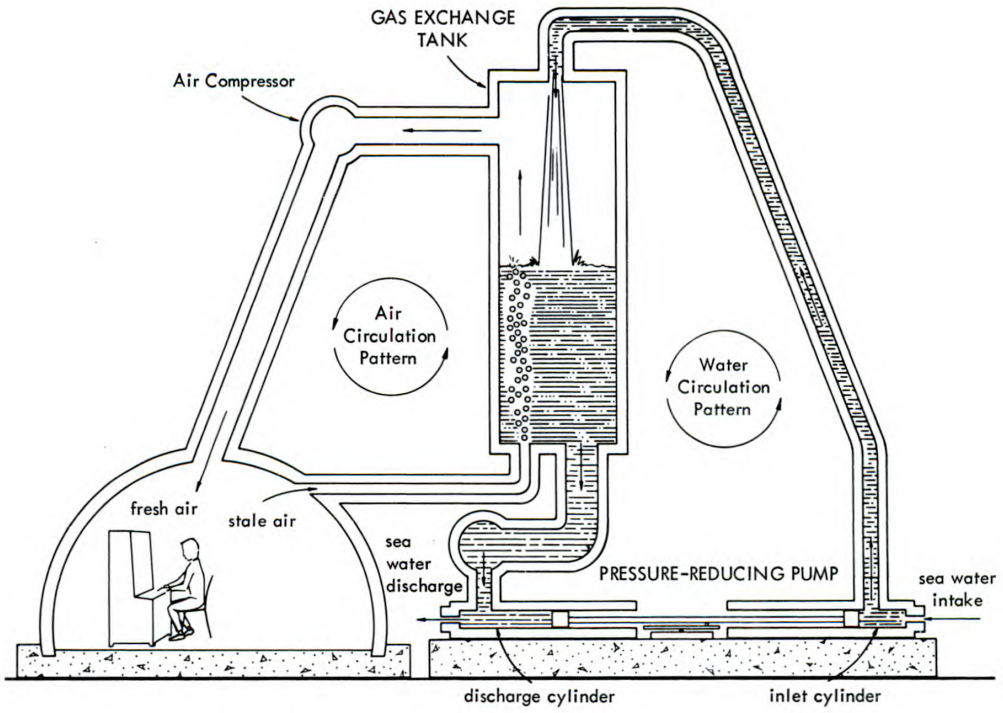
The new thesaurus will contain approximately 1,000 pages and list more than 23,000 main terms with generic relationships, cross references, and indexes. Terms are not defined but joined with specific descriptors to limit and clarify the scope of their meanings. For example, the term "atmosphere" has been divided into four basic terms—earth atmosphere, stellar atmosphere, planetary atmosphere (for planets other than earth), and controlled atmosphere (interior environments). Plasma is clarified by the basic terms blood plasma, plasma arcs, and plasma radiation. In many cases cross references to related descriptions are made to further pin down the use of the term.

The publication will replace the *Thesaurus of Engineering Terms,* which was issued by the Engineers Joint Council in 1964, as well as numerous thesauri and terminology lists now used throughout DOD, primarily the *Thesaurus of ASTIA Descriptors* issued in 1962 and used by the Defense Documentation Center (formerly ASTIA). The EJC had initiated its own program to revise its 1964 thesaurus at about the same time that Project Lex was started. It was agreed to combine operations, and the EJC provided full-time consultants to Project Lex.

The new volume is based on the earlier publications but expanded to include essential terminology in the biological, physical and social sciences. Some 145 organizations contributed thesauri, indexes and reference lists of terms, along with data concerning them. More than 1,250,000 items were received. In addition, more than 300 engineers and scientists from government, industry and education were consulted. Computer techniques were employed to support the entire task.

Distribution within the Federal Government and to its contractors will be through the Defense Documentation Center, Defense Supply Agency, Cameron Station, Alexandria, Va. 22314. An announcement will be made by DDC when copies are ready for distribution. The engineering community and the general public can purchase copies from the Engineers Joint Council, 345 E. 47th Street, New York, New York 10017. A magnetic tape version of the thesaurus with programs for computer manipulation will also be made available.

New Undersea Air-Supply System



With increased deep ocean exploration comes the problem of supplying a breathable atmosphere to possible undersea manned habitations of the near future. Accordingly, the U.S. Naval Civil Engineering Laboratory, Port Hueneme, California has developed a simple system of producing breathable air from seawater. The system is self-contained in the undersea dwelling.

Most systems for providing air to undersea chambers are complicated and costly. They usually consist of producing oxygen by electrolysis of seawater, piping air from the surface, or transporting bottled air to the ocean depths.

The system devised by Dr. Harold P. Vind of NCEL's Chemistry Division uses basically a tank, some tubing, and a pressure-reducing pump. It operates on the principle of exchange: Oxygen-deficient stale air is forced into a gas-exchange tank where it meets a continuously circulating stream of seawater. The surfaces of the many droplets and bubbles serve as inexpensive diffusion membranes and play the role often played by synthetic membranes in other processes. The excess carbon dioxide in the stale air diffuses into the seawater and the oxygen in the seawater diffuses into the oxygen-deficient stale air. Then the revitalized air, recharged with oxygen, is returned to a sealed chamber for use by men or animals; and the waste seawater, depleted of oxygen and charged with carbon dioxide, is returned to the ocean.

In returning the waste seawater to the ocean, the pressure-reducing pump plays a key role. Because of the great pressure difference between the inside and outside of an undersea chamber, an ordinary pump would have to be very powerful to discharge the water into the ocean. The new pump couples the high pressure at the seawater intake with that at the discharge opening in such a way that the intake pressure is essentially the force that pushes the used seawater through the discharge valve. Thus, practically the only power required for the pump's operation is that needed to overcome the friction of the components.

Rats have lived comfortably for eight hours in a sealed chamber served by the NCEL system.

The new method for extracting oxygen from seawater grew out of experiments aimed at ventilating future undersea Seabee bases. The Navy has plans for undersea installations and construction bases at various depths, and the Seabees will, no doubt, be busy there. The next step in development of the air supply system will be the building of a pilot plant to further evaluate the achieved laboratory process.

Possible uses of the NCEL air-supply system include service to (1) rest stations for scuba divers at depths of 100 feet; (2) undersea vehicles and work platforms in shallow depths; (3) undersea construction bases, observation chambers, and other installations of various types in which pressure is equalized inside and out; and (4) hard-shelled shelters or submarine vehicles at any depth in which pressure is maintained at, or near, the pressure existing at the surface.

NRL Develops New Preservative-Lubricant

Naval Research Laboratory chemists, responding to a need in Southeast Asia for improved maintainability of small arms weapons, have developed a new preservative-lubricant which has proven to be highly effective even when applied under combat conditions.

The new product, which is composed of a wax which adheres through polarization and a small amount of lubricating material, is easily applied from aerosol dispensers with only normal field disassembly of the weapon. The coating penetrates close clearances in assembly pins, spring housings, and other tight assemblies. In addition to being extraordinarily water repellent and a potent rust inhibitor, it "heals" areas which become scratched after application. The liquid lubricant creeps into such scratches, carrying a small amount of the polar wax with it.

The preservative-lubricant is extremely easy to work with. When tested in combat, a six-ounce can lubricated one weapon for ten days. It can be used at any time whether the gun is wet or dry, during an operation or behind the lines.

In a letter to CAPT T. B. Owen, director of the Naval Research Laboratory, RADM A. R. Gralla, Commander of the Naval Ordnance Systems Command stated that "tests have proved that the NRL-developed material is far superior to other standard military and commercial materials."

The material was originally intended for use on the M16 submachine gun in environments which include exposure to saltwater, beach landing incidents, and jungle activity. However, it has potential for use on any equipment with metal parts.

Plasma Physics Program Expanded

The Naval Research Laboratory and the Cornell University will expand their joint program in plasma physics to include research in gas lasers.

Scientists at the Laboratory will work closely with students and faculty at Cornell, renowned for its expertise in high-voltage engineering and laser physics technology which are fundamental in laser work. NRL research in gas lasers is directed toward determining the limitation of high-power laser systems.

The original joint research program was formalized last June. In addition to significantly increasing the scientific breadth of the participating institutions, the program acquaints graduate students with the research frontiers in the field of plasma physics through association with leading scientists.

Communications and Monitoring Center for Sealab III

A communications and monitoring center is being built for the U.S. Navy's Sealab III experiment planned for late 1967. The center, to be housed in two vans on the surface support vessel, will serve as the key information link between topside personnel and the aquanauts in the undersea habitat. Also, specialized equipment in the vans will monitor biological functions of the men and their equipment.

Sealab III, the third in a series of Sealab tests conducted under the Man-in-the-Sea program, is designed to gain additional technology needed to permit man to live and work for extended periods beneath the sea on the world's continental shelves.

The center will include four systems—medical, communications, atmosphere monitoring and instrumentation recording. Scheduled for delivery July 16, 1967, the two 26′ × 8′ vans are the first integrated communications and monitoring stations specially built for the Sealab series of experiments.

One van consists of a complete biochemical laboratory and an atmosphere monitoring station. The laboratory is equipped to perform a variety of biomedical tests and measurements. Two gas chromatographs in this van will continually sample the atmosphere in the Sealab habitat, the Personnel Transfer Capsule, and the two deck-compression chambers. Also, the monitoring station will be linked to the habitat by a closed-circuit TV system.

The second van will house both the primary and secondary communications system, each complete with audio facilities and closed-circuit TV monitors. A video tape recording machine will also be installed in the van. Instrumentation recording will be by strip-chart recorders (for monitoring purposes) and by magnetic computer for engineering analysis.

Areas to be monitored include atmosphere gas control equipment, diver excursion air supply, gas storage equipment attached to the habitat, atmosphere conditioning equipment, electrical power, fresh water system, and the temperature controls of the habitat atmosphere and equipment.

Nortronics Division of the Northrop Corporation is designing the vans and installing the equipment under a contract to the Deep Submergence Systems Project.

Ocean Depths Measured by Aerial Photography

Techniques for using aircraft to acquire in-flight data suitable for charting the ocean bottom were recently tested by the Naval Oceanographic Office. The flights were conducted off the Florida Keys.

To insure the accuracy of each of the six major photographic missions flown, the underwater site was first reconnoitered and marked with colored canvas targets which were securely fastened to the bottom at selected depths. To eliminate excessive distortion due to currents, each target was stretched taut over a heavy metal frame. Targets were placed at depths of 10, 20, 30, 40, 50, and 70 feet.

During each photo mission meteorological and oceanographic data were recorded by scuba divers and surface teams located in both the general target area and near 100 × 100-foot colored land targets.

In the past the U. S. Navy has made only limited tests for determining water depths from stereoscopic pairs of photographs. Although results from the mission are not yet fully known, it is hoped that water depths, illumination and bottom topography may be determined through the use of color photography.

On the Naval Research Reserve

Promotion Selections

One thousand two hundred and three Naval Reserve line officers were selected for promotion to the grade of lieutenant commander by the Fiscal Year 1967 Reserve Selection Board. Of this number, 31 Research Reservists were selected. Congratulations to:

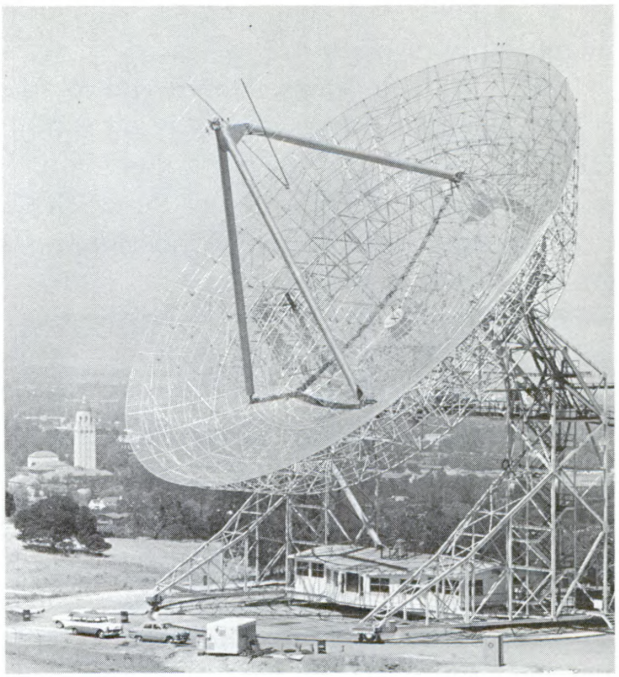
	NRRC		*NRRC*
Almgren, David W.	1-1	Greenlee, Wilfred M.	9-20
Bolster, Robert N.	5-9	Jones, Harry L.	8-5
Brainerd, Walter S.	9-7	Lynch, Robert B.	12-9
Briggs, Carroll G.	12-3	McWhorter, William C.	6-3
Buker, Fred M., II	1-1	Miller, Allen L.	9-21
Cappellari, James O., Jr.	5-10	Nelms, Harry A.	6-3
Carter, James G.	13-1	Penegar, Kenneth L.	6-6
Clark, Harold W.	11-9	Post, Arthur H., Jr.	1-1
Comstock, Craig	4-4	Rodgers, Tommie J.	13-6
Cook, Frederick J.	3-4	Rohm, Edward L.	4-4
Cromer, Arthur O.	9-7	Romano, William S.	3-9
Dudziak, Donald J.	8-9	Simpson, Leonard	12-5
Eldredge, Hugh G., Jr.	6-18	Sink, John D.	4-4
England, Loy D.	8-5	Stanford, L. B. (Selected FY 1966)	9-6
Forsyth, Carleton B.	5-9	Wilcox, Loren L.	9-4
Gartmann, Russel J.	4-1	Wilder, Donald R.	3-4

Statistics based on the records of the Research Reservists selected for promotion are as follows:

Year of Birth		*Year of Rank*	
Latest	1936	Latest	1962
Median	1934	Median	1960
Earliest	1928	Earliest	1956

Designator	*Education Level*	
1105:25	Bachelor	19
1355:2	Master	8
1405:3	Ph.D	4
1515:1		

San Francisco Bay Area Naval Reserve Activity



Seminar participants inspected the 150-ft dish antenna at Stanford University. Stanford's Hoover Tower can be seen in the background.

Because of the emphasis currently being placed on astrophysics activities by leading nations of the world, it is especially appropriate that Naval Reserve officers be well-versed in current space activities.

Seventy-five Naval Reserve officers in the San Francisco Bay Area devoted Saturday and Sunday, April 15 and 16, to an Astrophysics Seminar at Foothill College, Los Altos and Stanford University. Units represented were NRRC 12-1, NRRC 12-3, NRRC 12-4, NRRC 12-5, and NRRC 12-6. The sponsoring activity was Naval Reserve Officers School 12-2.

The program chairman, LCDR Thad J. Kowall, USNR, former executive officer of NRRC 12-3, is presently an instructor in Meteorology at NROS 12-2 in San Jose, California. LCDR Kowall specializes in infrared optics as applied to re-entry physics at Lockheed Missiles and Space Company, Sunnyvale, California.

The group inspected both the 80-foot and the 150-foot dish antennas at Stanford University and were introduced to experiments with Pioneer spacecraft. CW radio signals at both 50 MHz and 425 MHz are transmitted from the big dish, and their phase change as a function of time upon arrival at the spacecraft measured and telemetered back to Earth. There are instruments on board the spacecraft designed to measure the environment at the vehicle. The Stanford University experiments, however, are designed to gain information on the "licking tongues of plasma" in space between the Pioneer and Earth which might not be observed otherwise.

Seminar participants, including RADM Carl Watson, USNR, also viewed a planitarium display in the 30-foot diameter Foothill College facility. CDR P. E. Trejo, USNR, manages the facility and also designed many of the displays.

LCDR William Jones, USNR, NRRC 12-3's Executive Officer, discussed the application of computer simulations in plasma physics to the solar wind-earth magnetic field interaction. LCDR Jones is a research scientist at NASA-Ames Research Center.

A highlight of the seminar was the presentation of a series of photographs of solar flare activity over the past several years. This work, which was done by Lockheed Missiles and Space Company Solar Observatory at Burbank, California, is now assuming immediate importance in connection with the study of the health hazards of space flight for astronauts.

Joint Field Trips Sponsored by NRRC 12-5

To provide greater opportunities for field trips, NRRC 12-5 of Berkeley, California, has scheduled two meetings yearly—in the spring and fall—for Saturday mornings instead of the usual weekday evening. NRRC's 12-1, 12-2, and 12-3 of San Francisco, Livermore, and Palo Alto, respectively, are invited to participate, thus providing a joint meeting of all the Research Reserve companies in the San Francisco Bay area.

The first such meeting was held in October 1966 on board the USS(N), ENTERPRISE. The ship's officers gave an excellent presentation on the Naval Tactical Data System and how it affects modern ClC operations. Problem areas which deserve additional research efforts were also discussed.

Work done at Lockheed Missiles and Space Co. was the subject of the May trip. Both trips were established on a classified basis to permit the speakers maximum latitude in presenting their topics.

Bay Area Research Reserve Officers Judge 18th International Science Fair Entries

Twenty-four officers from Research Reserve Companies 12-1, UC Medical School, San Francisco; 12-2, Lawrence Radiation Laboratory, Livermore; 12-3, UC Berkeley; and 12-5, Stanford University acted as judges at the Eighteenth International Science Fair held May 8-13, 1967 at Brooks Hall in San Francisco.

Over 500 entries were submitted and numerous awards were presented. The Navy gave 10 Science Cruiser Program awards and one trip to the Japan Student Science Awards, which will be held in Tokyo

in January 1968. This year, for the first time, the 10 Navy Science Cruiser winners will be given employment at an appropriate naval laboratory during July and August.

Officers participating in this program were:

NRRC 12-1:

CDR Robert M. Wagner
LCDR Louis H. Davy
LCDR Muriel E. Johnston

NRRC 12-2:

CAPT R. C. Preston
LCDR Hans G. Birnbaum
LCDR Robert L. Chapman
LCDR J. E. Van Hoomissen

NRRC 12-3:

CDR B. F. Gillette
CDR J. P. Steward, Jr.
LCDR H. M. Blume, Jr.
LCDR D. R. Campbell
LCDR M. H. Childs
LCDR Allen J. Chinn
LCDR C. E. Fuller
LCDR W. P. Jones
LT R. J. Fisher

NRRC 12-5:

CAPT E. M. Blue
CDR H. R. Frisbie
CDR G. W. Hamilton
LCDR Owen Cort
LCDR C. F. Spencer
LCDR W. D. Thomas, Jr.
LT G. C. Johnson
LT D. J. Koupal

Random Noise

Dr. Harry H. Hess, a Consultant to the Naval Oceanographic Office, Suitland, Md. and Chairman of the Department of Geology at Princeton University, has been appointed by President Johnson to the President's Committee on the National Medal of Science.

Dr. Alfred A. H. Keil, Technical Director of the then David Taylor Model Basin from 1963 to 1966, became the second recipient of the Gibbs Brothers Medal of the National Academy of Sciences on April 24. The award recognized his achievements in the physics of underwater explosions and their effect upon ship structures and cited his dynamic leadership of the technical and research activity of DTMB. Dr. Keil is now Professor and Head of the Department of Naval Architecture and Marine Engineering at the Massachusetts Institute of Technology.

Mr. Howard O. Lorenzen was recently appointed Superintendent of the NRL Electronic Warfare Division. In this position, Mr. Lorenzen will administer NRL's program of conducting studies and developing techniques in support of the Navy's electronic warfare mission.

Dr. Ralph Roberts, Head of ONR's Power Branch, has been elected treasurer of the newly formed Eastern Section (United States and Canada) of the International Combustion Institute.

Selected Contract Research Reports

The contract research reports listed below have been extracted from the Technical Abstract Bulletins 67-7 and 8 of April 1 and 15, 1967. Government agencies and their contractors who are registered with the Defense Documentation Center of the Defense Supply Agency may obtain *free* copies from the Center at Cameron Station, Alexandria, Virginia 22314. Abstracts of the reports are found in TABs 67-7 and 8.

For non-DDC users, most reports may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Department of Commerce, Springfield, Virginia 21151.

AERONAUTICS

Army-Navy Instrumentation Program. Fixed Wing Research Phase; Douglas Aircraft Co., Inc., El Segundo, Calif.; AD-647 297

Contact Analog Simulator Evaluation: Investigations of Director Symbols, Display Alterations, and the Presentation of Secondary Flight Information; Bell Helicopter Co., Ft. Worth, Tex.; Emery *et al;* AD-647 201

ASTRONOMY AND ASTROPHYSICS

Physics of the Solar Corona; Colo. U., Boulder; Billings; AD-647 075

An Interpretation of the Absorption Spectrum of 3C 191; CalTech.; Bahcall; AD-647 113

Solar Magnetic Fields; Lockheed-Calif. Co., Burbank; Smith; AD-647 305

Infrared Solar Spectra Taken from Balloon Altitudes; Johns Hopkins U., Baltimore, Md.; Strong and Zander; AD-647 501

Basic Solar Research; Mich. U., Ann Arbor; Mohler; AD-646 372

On the Alpha Width of the 7.12-MeV State of Oxygen and the Products of Helium Burning; CalTech., Pasadena; Stephenson; AD-646 784

A Mechanism for Mass Ejection in Red Giants; CalTech.; Wickramasinghe *et al;* AD-646 787

The Iron Group Elements and the Equilibrium Process in Nucleosynthesis; CalTech.; Fowler; AD-646 788

Solar Filament Structure; Lockheed-California Co., Burbank; Ramsey and Smith; AD-646 849

ATMOSPHERIC SCIENCES

Skyhook 1966; Schjeldahl (G T) Co., Northfield, Minn.; Merrell and Schafer; AD-647 271

BEHAVIORAL AND SOCIAL SCIENCES

A Further Comparison of Some Models of Duopoly; Yale U., New Haven, Conn.; Shubik; AD-647 790

Instructional Film Research (Rapid Mass Learning) 1918-1950; Pa. St. U., Univ. Park; Hoban, Jr. and van Ormer; AD-647 255

Applications of the Theory of Games in the Behavioral Sciences; Tex. U., Austin; Buchler and McKinlay; AD-647 203

An Inquiry into the Structure of Attitudes and Behavior: A Validation Study; Ill. U., Urbana; Naidoo; AD-647 210

Frequency of Contact and Stereotyping; Ill. U., Urbana; Triandis and Vassiliou; AD-647 211

Leadership Style and the Performance of Co-Acting Groups; Ill. U., Urbana; Fiedler; AD-647 212

Estimating True-Score Distribution for Mental Tests (Methods 12, 14, 15); Educational Testing Service, Princeton, N. J.; Lord and Lees; AD-647 406

Estimating True-Score Distributions for Mental Tests (Method 16); Educational Testing Service, Princeton, N. J.; Lord and Lees; AD-647 409

Dimensions of Stimulus Situations which Account for Behavior Variance; Texas Christian U., Ft. Worth, Tex.; Sells; AD-647 466

Organizational Structure and Similarity of Campus Student Organizations; Texas Christian U., Ft. Worth; Findikyan and Sells; AD-647 531

Attitude Generalization in Social Triads as a Function of Personality Structure and Availability of Social Support; Princeton U., N. J.; Streufert; AD-647 639

The Use of Role-Reversal in Intergroup Competition; Columbia U., New York; Johnson; AD-647 697

Critical Incidents with Hetero-Cultural Interactions; Ill. U., Urbana; Stolurow and Santhai; AD-647 760

Methods of Analyzing Group Tasks; Ill. U., Urbana; O'Brien; AD-647 762

A Test of the Leadership Contingency Model in Three Organizations; Ill. U., Urbana; Hunt; AD-647 763

Program Planning for Research and Development in the Navy; Syracuse U., Wash., D. C.; Rosenberg and Bain; AD-646 497

LP II: A Goal Programming Model for Media Planning; Carnegie Inst. of Tech., Pittsburgh; Charnes *et al;* AD-646 918

A Chance-Constrained Approach to Capital Budgeting with Portfolio Type Payback and Liquidity Constraints and Horizon Posture Controls; Carnegie Inst. of Tech., Pittsburgh; Byrne *et al;* AD-646 723

Training Corrective Maintenance Performance on Electronic Equipment with CAI Terminals: A Feasibility Study; U. of S. Calif., Los Angeles; Rigney; AD-646 651

The Role of Trial in the Acceptance and Adoption of New Equipment: A Review and Summary; Life Sciences Inc., Fort Worth, Texas; Berger *et al;* AD-646 360

Factors Affecting Information Processing in Short-Term Memory; Mass. U., Amherst; Moss *et al;* AD-646 373

Generalizability of Game Playing Skill; Akron U., Ohio; Shriver; AD-646 377

Goals and Intentions as Determinants of Performance Level, Task Choice and Attitudes; American Institutes for Research, Silver Spring, Md.; Locke and Bryan; AD-646 392

The Human Orienting Reaction as a Function of Electrodermal Versus Plethysmographic Response Modes and Single Versus Alternating Stimulus Series; Indiana U., Bloomington; Furedy; AD-646 510

Molecular Neurochemistry of the Hippocampus and Other Brain Sites During Conditioned Avoidance Behavior; York U., Toronto (Ontario); Gaito *et al;* AD-646 701

A Frequency Theory of Verbal-Discrimination Learning; Northwestern U., Evanston, Ill.; Ekstrand *et al;* AD-646 705

Strategies of Inducing Cooperation: An Experimental Study; Columbia U., N. Y.; Deutsch *et al;* AD-647 801

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The 1967 Gordon Research Conference on Photonuclear Reactions will be held at the Tilton School, Tilton, N.H., August 14-18. Additional information on this conference, which is co-sponsored by ONR, may be obtained from Dr. P. Yergin, Rensselaer Polytechnic Institute, Troy, N.Y.

CDR Rhodes Boykin, Jr. Receives Navy Commendation Medal

CDR Boykin (right) receives Navy Commendation Medal from RADM Leydon.

CDR Rhodes Boykin, Jr., formerly the Senior Submarine Warfare Officer, Underseas Programs, Office of Naval Research, recently received the Navy Commendation Medal. The medal was presented by RADM John K. Leydon, Chief of Naval Research during a ceremony held April 13, 1967.

The citation, which was signed by the Secretary of the Navy, reads as follows:

> "For meritorious service from June 1965 to April 1967 while serving with the Office of Naval Research. As project officer, Commander Boykin consistently carried out his duties with outstanding technical ability, professional skill and diplomacy, contributing directly to the success of the Deep Research Vehicle program which has resulted in distinct and immediate advantages to the United States Government. In addition to being responsible for the administration, management and planning of this novel and difficult research project, he participated directly in operations which led to the successful search and recovery in April 1966 of a U. S. nuclear device which was lost off Palomares, Spain, following a collision of two U. S. aircraft. Commander Boykin's outstanding leadership, technical ability and loyal devotion to duty reflect great credit upon himself and the United States Naval Service."

ALVIN, the Navy's deep diving research vehicle was accepted in 1965. That same year, CDR Boykin became Project Officer for the program and has supervised all of ALVIN's operations since the early test dives. These operations included the successful inspection of ARTEMIS underwater installation conducted at depths from 3000 to 6000 feet

and participation in the search and recovery of the lost hydrogen bomb off the coast of Spain in 1966.

During the hydrogen bomb search and recovery operations, CDR Boykin served as operations officer for ALVIN and its support vessel. His performance resulted in a most successful operation during which ALVIN made 34 dives in 53 days, culminating in location of the bomb and a second location after first recovery operations failed.

As a result of ALVIN's early successful operations, it was decided to build two similar vehicles—ALVIN II for ONR and an AUTEC vehicle for the Naval Ship Systems Command. CDR Boykin was the individual most responsible for this expanded program. He was also instrumental in arranging a Workshop on Deep Research Vehicles in 1966, where representatives of organizations in the United States and many foreign countries met to discuss problems, progress and plans for the construction and operations of deep research vehicles.

In addition to receiving the Navy Commendation Medal, CDR Rhodes Boykin has been decorated for service in the Korean War and the China Theatre. He has received the National Defense ribbon and the United Nations award.

CDR Boykin is currently assigned to Commander Carrier Division 16, Norfolk, Virginia.

Dr. Shapiro Receives Navy Distinguished Civilian Service Award

Dr. Maurice M. Shapiro, an internationally recognized nuclear physicist, and one of the foremost authorities in the field of cosmic radiation, received the Navy Distinguished Civilian Service Award on April 25, 1967. Presentation of the award, the highest available

Dr. Robert A. Frosch (right), Assistant Secretary of the Navy for Research and Development, presents the Navy Distinguished Civilian Service Award to Dr. Shapiro.

to civilian employees of the Navy, was made by Dr. Robert Frosch, Assistant Secretary of the Navy for Research and Development.

Dr. Maurice M. Shapiro, Chief Scientist of the Laboratory for Cosmic Ray Physics at the Naval Research Laboratory, was honored for "his scientific leadership and his investigations in cosmic radiation, elementary particle physics, and nuclear physics." He was particularly cited for his pioneering applications of nuclear emulsion methods to high-energy physics.

As Chief Scientist of the Laboratory for Cosmic Ray Physics, Dr. Shapiro heads a group investigating the composition, energy spectra and other properties of ultra-high energy particles known as cosmic rays which constantly bombard the top of the Earth's atmosphere from outer space. He was principal investigator for Gemini Cosmic Ray experiment S-9, a collaborative project with the Goddard Space Flight Center.

Last year the Naval Research Laboratory established a Chair of Cosmic Ray Physics to confer special recognition on Dr. Shapiro. He had served since 1953 as Superintendent of the Nucleonics Division at the Laboratory. In 1965 he resigned from that position to concentrate on astrophysical research.

A native of Jerusalem, Palestine (now Israel), Dr. Shapiro received his Ph.D. degree in Physics from the University of Chicago in 1942. He pioneered in the powerful photographic emulsion method of detecting cosmic rays and other nuclear particles at that school. He also received his Bachelor of Science and Master of Science degrees at the University of Chicago.

During World War II, Dr. Shapiro carried out underwater research for the Navy and served as a Group Leader at the Los Alamos Scientific Laboratory. Prior to coming to NRL in 1949 to organize the Cosmic Ray Branch, he worked on neutron and fission physics at the Oak Ridge National Laboratory.

In 1962, Dr. Shapiro was awarded a Guggenheim Fellowship and spent his sabbatical as Visiting Professor of Physics at the Weizmann Institute of Science, Rehovoth, Israel. He served as chairman of the U. S. International Geophysical Year Committee on Interdisciplinary Research and is a former President of the Philosophical Society of Washington, a Fellow of the American Physical Society and the American Association for the Advancement of Science, and a member of the Italian Physical Society, the Scientific Research Society of America, and the Washington Association of Scientists. He has authored more than 100 scientific publications and reports.

New NRAC Chairman, Vice Chairman Appointed by Secretary Nitze

Dr. W. Deming Lewis, president of Lehigh University, Bethlehem, Pa. has been named by Secretary of the Navy Paul Nitze to be Chairman of the Naval Research Advisory Committee (NRAC), replacing the retiring Chairman, Mr. Garrison Norton. Dr. Lewis has been serving as Vice Chairman of NRAC. Filling that post will be Mr. Edward Heinemann, Vice President of Engineering, General Dynamics Corp.

Congress established NRAC simultaneously with the establishment of ONR by Public Law 588 on August 1, 1946. The Committee, which consists of persons preeminent in the fields of science and research, both in industry and the academic world, acts as the senior scientific advisory group to the Secretary of the Navy, the Chief of Naval Operations and the Chief of Naval Research.

Dr. Lewis is a leader in space and communications programs. Before his appointment as president of Lehigh in 1964, he was associated with the Bell System. He served as

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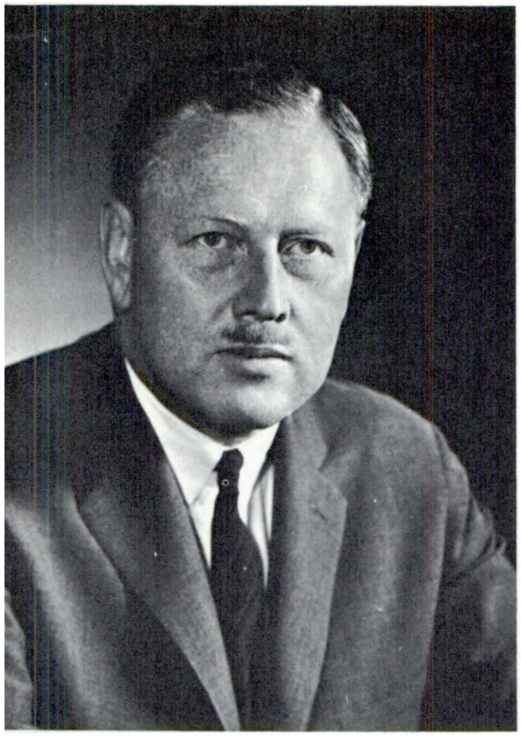

Dr. W. Deming Lewis

Mr. Edward Heinemann

Executive Director, Research-Communications Systems at the Bell Telephone Laboratories, and was one of four scientists who initiated Bellcom, Inc., the Bell System subsidiary devoted chiefly to system engineering for NASA's Apollo Project in 1962.

Mr. Heinemann, a veteran in aircraft design, started with the Douglas Aircraft Company in 1926. He was made chief engineer for Douglas, El Segundo in 1936 and became Vice President, Military Aircraft at Douglas in 1958. Winner of the Collier Trophy in 1953 and other top awards in his field, he has occupied his present position with General Dynamics since 1962.

Other members of NRAC are:

Dr. Harvey Brooks, Dean, Division of Eng. and Applied Physics, Harvard;

Dr. William A. Fowler, Kellogg Radiation Laboratory, Cal Tech;

Dr. Clifford C. Furnas, President, Western New York Nuclear Research Center, Inc.;

Dr. Richard A. Kern, Temple University Hospital;

Dr. Augustus B. Kinzel, President of the Salk Institute;

Dr. Isidore I. Rabi, University Professor, Columbia University;

Dr. Roger Revelle, Director, Center for Population Studies, Harvard;

Dr. Frederick Seitz, President of the National Academy of Sciences;

Dr. O. G. Villard, Director, Radioscience Laboratory, Stanford University;

Dr. James H. Wakelin, Jr., former Assistant Secretary of the Navy (R&D);

Dr. Eric A. Walker, President of Pennsylvania State University ·

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NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 109, Office of Naval Research, Washington, D.C., 20360. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

NAVSO P-510

One of the more fascinating research projects in the Human Factors Engineering program is the development of a powered exoskeleton. Research is being jointly sponsored by the Army and the Navy. One promising application for this device is for underwater construction, salvage and rescue operations. *See article beginning on page 1.*